CHAPTER IV
SOLID WASTE MANAGEMENT AND MARINE POLLUTION

I. INTRODUCTION

Ocean basins are final resting places for all solid particles that can be moved about on the earth’s surface. In this respect they are traps, which record the earth’s history bit by bit as each particle is delivered to their keeping. Ocean possesses self-purification capacity and hence mankind tends to regard ocean as a convenient and limitless receptacle for planetary waste. So the ocean disposals of different types of hazardous and deleterious substances have grown at an exorbitant pace. Throughout the centuries the ocean disposal of solid waste has taken place, primarily in to the rivers and estuaries that empty in to the oceans. Many nations continue to use the ocean as an ongoing depository for wasters that are generated within their borders. For example, U.S. National Advisory committee on ocean’s and Atmosphere (NACOA) has estimated that the United States produces approximately three billion tons of solid waste annually, and during 1979, U.S. alone has dumped 8,652,998 tons of wastes directly in to the ocean. It is apparent from the above stated figure that the International Solid Waste Problem is enormous and need immediate attention.

1 Alyn C. Duxbury, Earth and its oceans, University of Washington, Addison-Wesley publishing company Chapter 5, Page 94, first Para.
2 Ibid.
3 NATL Advisory Committee, Oceans and Atmosphere, The role of the ocean in a waste management strategy 43 (1981)
4 43 cath. U.L.Rev>37
Further, there is no authoritative estimation regarding the total world wide quantities of solid waste generation and its disposal into the oceans. But in fact every waste that is generated on land eventually find their way in to the oceans. According to estimation, only 10% of the pollutants enter the ocean through the direct dumping and remaining portion enters the ocean incidentally via run-off by water ways, landfill leachet\(^5\) and atmospheric fall out etc.

II. DEFINITION OF WASTE

\textit{21\textsuperscript{st} centuries chambers dictionary} has defined the term wastes as “To throw away.” In general waste means “something, which is not put in to proper usage at a given time.”

\textit{Alexander kiss}, in his book entitled “the International control of Transboundary movement of Hazardous waste, defines waste as “resderilicata” (the abandoned object), which corresponds to the concept of “Throw away” culture.

\textit{Basel Convention 1989}\(^6\) defines waste as substances or objects, which are disposed or are intended to be disposed or are required to be disposed of under the provisions of national laws. This meaning does not prescribe hazardous nature of the waste and depends upon national laws to categorize waste substances\(^7\)

\textit{United Nations Statistics Division (UNSD)} has described wastes as materials that are not prime products, for which the generator has no further use for the purpose of production, transformation consumption,” Thus UNSD meaning has also failed to

\(^5\) Leachet is a liquid that generated in the landfill digester and stored in the bottom of the landfill as a result of chemical reaction occurred in the landfills.

\(^6\) For the detail provisions of the Basel convention see appendix to the thesis.

\(^7\) Vishnu Konoorayar and Jaya V.S, disasters management law, Chapter three, page 41, Para 2.
consider the environmental impact of the waste and has merely described from the point of view of industry\textsuperscript{8}.

*Cambridge Learner’s Dictionary*, Cambridge University Press 2001 defines waste as “Waste actually includes something and causes a lot of harm or damage”.

*Oxford Dictionary*, Public advisory panel of the chemical manufacturers association USA has defined waste as “Any gas, liquid, or solid residual material at facility, whether hazardous or non hazardous that is not used further in the production of a commercial products or provision of a service which itself is not a commercial product, is waste”\textsuperscript{9}.

The definition given by the Oxford dictionary is exhaustive and describes the nature of waste based on its environmental impact. According to this definition, a product can be considered as waste when it is not useful for any purpose. Hence reusable wastes produced by various industries, factories or by any other sources, cannot be considered as waste. Therefore waste means any thing which has lost its usefulness.

### III. DEFINITION OF SOLID WASTE

In general, solid waste means “wastes, which are in solid form.” In particular, solid waste can be defined as “organic and inorganic waste materials produced by household, commercial, institutional and industrial activities that have lost their value in the eyes of first owner (Cointreau 1982).\textsuperscript{10} This definition has failed to cover the waste generated from the animal activities. According to the encyclopedia “solid wastes are all


\textsuperscript{9} Ibid

\textsuperscript{10} Isa Band and Hans Schenk, Solid Waste Management, modes, assessment, appraisals and linkages, Manohar publications, 1994, Chapter 2, Page no 8.
the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted because of their intrinsic properties\(^{11}\).

**IV. FEATURES OF SOLID WASTE**

The quantity and quality of solid waste is varies from one country to another country based on various factors like, percapita income of a particular nation, living style, social behavior, types of industries, techniques of reutilization of waste as a raw materials and finally market for waste etc.

1. Solid waste generation is a consequence of life and based on the percapita income of a country, that is if percapita income of a country is high then the ratio of solid waste generation is also high\(^{12}\).
2. Quality and quantity of solid waste is different from each country, and based on types and nature of agriculture and industries; means solid waste generation of industrialized nation is different from the solid waste generation of a nation whose prime occupation is agriculture.
3. The composition of solid waste differs from one season to another season and from one location to other location.
4. Solid waste generation largely depends on the living style, culture, standard of living of the population of a particular nation.
5. The size and growth of population plays a significant role in the solid waste generation.

\(^{11}\) William, Encyclopedia of solid waste,avishkar publications, Chapter 1 page no3, Para 1
\(^{12}\) Manoj Datta, waste disposal in engineered landfills. Indian Institute of Technology-Delhi page 27.
6. Solid waste generation is low if a particular country has adopted the waste reusable methods and engaged in waste marketing and similar activities.

7. Solid waste can be used as an alternate source of energy\textsuperscript{13}.

However, solid generation is technological society can be explained as follows.

The solid waste generation in technological society can be explained as follows.

\textbf{Figure-1 of chapter 4}\textsuperscript{14}

\textsuperscript{13}William, Encyclopedia of Solid waste, avishkar publications, page no 30-54.

\textsuperscript{14}Ibid, Page no 6, Chapter1.
V. TYPES OF SOLID WASTE

Based on the data that has been provided by the U.S. Council for Environmental Quality\(^\text{15}\), ocean disposable solid waste can be classified as follows.

1. Municipal Solid Waste

   a. Solid waste generated from residential and commercial establishments.

   b. Institutional solid waste.

   c. Solid waste from construction and demolition.

   d. Solid waste from municipal services.

   e. Solid waste from waste treatment plants.

   f. Special waste.

2. Agricultural solid waste.

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\(^{15}\) U.S Council for Environmental Quality (CEQ) has identified 7 types of ocean disposed wastes

1. Dredge Spoils: It includes solid materials removed from the bottom of water bodies generally for the purpose of improving navigation, sand, silt, clay, rock and pollutants that have been deposited from municipal and industrial discharges. Recent example of marine pollution from dredge spoils is Setu samudram issue.

2. Industrial wastes, which include wastes from refinery, pesticide industries, paper mills, and also assorted semi liquid wastes.

3. Sewage sludge, which means the solid material remaining after municipal waste treatment, it also includes residual human waste and other organic and inorganic wastes.

4. Construction and demolition debris, which includes, masonry, tile, stone, plastic, wiring, piping, shingles, glass, cinder block tar, tarpaper, plaster, vegetation and excavation dirt etc.

5. Solid waste which is more commonly called as refuse, garbage or trash, these are the materials generated from residences, commercial, hospitals and industrial establishments. Waste that generated from municipal operations, agricultural wastes, food waste, garden wastes, steel and glass containers and also other miscellaneous materials.

6. Explosives and chemical munitions, which also includes unserviceable or absolute shells, mines. Solid rocket fuels and chemical warfare agents.

7. Radio Active Waste : It includes both liquid and solid wastes that results from processing of irradiated fuel elements, nuclear reactor operations, medical use of radio active isotopes and research activities and from equipment and containment vessels, which become radioactive by induction.\(^{15}\)
3. Hazardous solid waste

   a. Hazardous solid wastes from industrial establishments and mining activities.

   b. Biomedical solid waste.

   c. Municipal hazardous solid waste.

4. Radioactive waste

5. Solid waste that is generated due to the vessel and sea bed activities.

6. Atmospheric dumping and soil substances.

1. Municipal Solid waste:

   Municipal solid waste is those wastes that are generated from the residential areas, commercial establishments, institutions, municipal services, waste treatment plants and also from the construction and demolition activities. Segregation of municipal solid waste is a difficult task, but once it has separated, then it is easy to manage municipal solid waste. However, municipal solid waste can be further classified as follows.

   a. Solid waste generated from residential and commercial establishments:

       Organic fraction of residential and commercial solid waste includes the materials like paper of all types, card boards, plastics, textiles, rubber, leather, wood, and yard waste. It also includes the inorganic fractions like glass, crockery, tin cans, aluminum, ferrous metals, and dirt, etc. If the waste components are not separated at the time of its disposal, such mixture of waste is known as coming-led waste. Municipal waste
contains 40 types of waste papers e.g.: books, magazines, commercial printing, office paper, packing and non packing papers, tissue paper, towels etc.

Plastic materials found in municipal solid waste fall into the following 7 categories.

a. Poly ethylene terephthalate (PETE)
b. High-density poly ethylene (HDPE)
c. Poly vinyl chloride (PVC)
d. Low – density polyethylene (LDPE)
e. Poly propylene (PP)
f. Polystyrene (PS)
g. Other multi layered plastic materials.

The mixture of these 7 types plastic waste is called as mixed plastic.

b. Institutional Solid waste:-

The term institution includes government centers, schools, prisons and hospitals etc and the waste that generated from these institutions are called as institutional waste. The institutional waste does not include the manufacturing waste from prison and medical waste from hospitals, because these wastes come within the meaning of industrial waste and Bio-medical waste respectively. However, solid wastes that are generated at these institutions are quite similar to coming led municipal solid waste. For example, paper waste, cardboards, plastic wastes, rubber leather, wood, yard waste, glass

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16 Presently wastes generated from hospitals are not considered as institutional waste. These wastes are now called as biomedical waste and governed by separate law.
pieces, dirt, etc. Therefore there is not much difference between residential, commercial and institutional waste.

c. Waste from construction and demolition popularly known as C and D waste

Generally wastes generated due to the construction, remodeling and repairing of individual residence, commercial establishments or from any other structures are considered as construction and demolition waste. The Department of Environmental Protection, Florida defined the C and D waste as “discarded materials, which are non water soluble and non-hazardous in nature. It includes glass, brick, concrete, asphalt material, pipe gypsum, wall board, and lumber, from the construction or destruction of a structure as a part of construction, demolition or renovating activity.”

Generally, rock, soil, tree remains, trees and other vegetative matter, which normally results from land clearing or land development operations for a construction project. The produced quantity of C and D waste is difficult to estimate and the composition of C and D waste may be vary from each nation and also to each project. Again, the composition of C and D waste depends on the mode of construction and usage of material etc. Coastal C and D waste and waste from coastal engineering activities are largely contributes to the marine pollution.

d. Solid waste from Municipal Services

Waste from street sweeping, road side litter, waste from municipal litter containers, landscape and tree trimmings catch-basin debris, dead animals and abandoned

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17 See guidance for disturbance and use of old closed land fills or waste disposal area in florida-May-3-2001 Department of environmental protection Florida-solid waste section page no 2.
vehicles are called solid waste from municipal services. There is not much difference between municipal solid waste and solid waste from municipal services. The first one is concerned with the collection of waste from residential units, commercial units and institutions whereas the second one is concerned with the collection of waste from municipal services.

e. Solid waste from treatment plants and other residues or sewage sludge

Solid, semi solid wastes from waste water treatment facilities are termed as sewage sludge. The specific characteristics of these materials vary and depending on the nature of the treatment process. Normally sewage sludge from waste water treatment plants is co-disposed with the municipal solid waste in municipal land fills. Sometimes sewage sludge may be used for agricultural purpose but its usage depends on the toxicity of the sludge. If sludge is toxic or hazardous in nature such sewage sludge commonly disposed with the municipal solid waste in land filling facilities. Again leachet from this land filling facility enters the ground water system and ultimately reach the marine.

f. Special Waste

Special wastes are those waste, which are generated from residential and commercial sources, and that are collected separately and handled separately are called as special waste. It includes bulky items\(^{18}\) consumer electronics\(^{19}\) white goods\(^{20}\) yard wastes, batteries\(^{21}\), oil and tires etc.

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\(^{18}\) Bulky items includes broken house hold commercial and industrial items like, furniture, lamps, book cases, filing cabinets and other similar items.

\(^{19}\) Consumer electronics includes broken and unwanted electronic items such as radio, stereos, television, computers, mobiles etc.
2. Agricultural Solid Waste

Agricultural solid waste means all wastes that arise due to all kinds of agricultural activities. It comprises

i. Manure and wastes from feed lots or from poultry houses.

ii. Fertilizer run-off from crop land.

iii. Harvest wastes

iv. Salt and silt drained from irrigated land or eroded land.

a. Pollutants from feed lots

Scientists believe that feed lots waste may seriously contaminate the receiving water because of its ready solubility in water. Feed lot wastes have high biological oxygen demands; their nutrients upset natural ecological communities and nourish plant growth. Water purification plants are taxed with increased burdens of sludge and it is not possible to eliminate these pollutants from the receiving water. Feed lot waste is also a decease causing pollutants, which enters the human body through biological magnification. Feed lot waste enters the marine environment through run-off on via water ways and occasionally by direct dumping.

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20 White goods include broken house hold, commercial and industrial appliances such as stoves, refrigerators, dishwashers, clothe washers and dryers.

21 Batteries from automobile industries and residential houses are the principle sources of batteries. House hold batteries come in verity of types including alkaline, mercury, silver, zinc, nickel and cadmium. The metal found in house hold batteries can cause ground water contamination by their presence in leachet, they can also contaminate air. Hence many states now prohibits disposal of house hold batteries to the land filling facilities. Automobiles batteries contain lead, acid, approximately 18 pounds and also sulphuric acid and hazardous material.
b. Fertilizer run off

Fertilizers contain nitrates and phosphates, which are considered as prime nutrients. These nutrients enter the oceans through run-off and water ways. These nutrients lead to excessive growth of aquatic weeds. Agricultural waste also includes plastic bags, discarded container, etc, which are mainly used to store fertilizers and pesticides etc. Therefore agriculture waste includes all waste that is generated during the agricultural activities.

c. Harvest Wastes

Straw left over from harvesting wheat, and other cereal grains, corn stalks, remains of plants and similar materials are considered as agricultural waste. Straw has been used as an absorbing agent in cleaning oil spills from surface and shore areas. Much of the wastes from harvests are spread over the top soil, (where materials eventually decay) to avoid soil erosion and to provide some enrichment for the soil. However lack of careful management of this procedure may harbor pests. After 1973, there has been increased interest in using fermentation to convert feed lot and harvest wastes into methanol.

c. Salt and silt drained from irrigated land or eroded land

Sediments include soil and mineral particles which get washed in to streams by storms. The present ratio of soil erosion is two or three times more than what it was before man’s intervention in to the nature. Some 3 ½ billion metric tons of sediments are washed into tributary streams each year; ¼ of this quantity being transported to the sea.
Urban developmental activities, industries, high way constructions and road banks are the major sources of sediments. Accumulation of sediments is a blessing to agriculture but curse to marine eco-system. Sediments will settle on throughout spawning beds and suffocate the eggs. It can clog gills of adult fish. It interferes with domestic and industrial uses of water and produces extra expenses to clean such water. It can lead to reduced dissolved oxygen levels and there by adversely affect aquatic life.

Accumulation of agricultural waste depends on the nature of agricultural activities, usage of pesticides, selection of crop etc. Countries of South Asian seas region are predominantly agricultural hence the ratio of production and consumption of fertilizers, pesticides are high. Further, pesticides used in this region normally contains chlorinated hydrocarbons like DDT, adrin and deldrin. The DDT is most widely employed chlorinated hydrocarbon together with a lesser extent of adrin and deldrin. These are highly stable compound but once released they persist in the environment and long after the input ceases. Normally contents of pesticides and fertilizers enter the aquatic species and human body through the biological magnification and causes great harm to the human as well as aquatic life.

3. Hazardous waste

Hazardous wastes, in general means waste or combination of waste that pose a substantial or potential hazard to human or other living organisms because of the following reasons.

\[22 \text{ Total DDT concentrations in Indian Ocean are higher than those found in any of the other oceans except the North pacific.}\]
\[23 \text{ P.C Sinha, coastal and marine disaster. Anmol publications, Page no 95.}\]
a. Such wastes are non-degradable or persistent in nature.
b. They can be biologically magnified.
c. They can be lethal
d. They may otherwise cause or tend to cause detrimental cumulative effects.

Basel convention has provided an elaborate list of hazardous wastes in its annexure part. In 1979 U.S Environmental Protection Agency has prepared a list of hazardous pollutants. This list is based on the following four criteria’s.

They are:

1. Actual or potential damage that occurs due to the discharge of these materials into water by virtue of certain toxic properties. These properties include bio-accumulation carcinogenicity, mutagenicity, teratogenicity and high acute toxicity.

2. Serious discharge or potential discharge of the pollutant by point source to the extent, that discharges have been identified.

3. Setting of effluent standards for point source discharges.

4. Over all environmental effect of the control measures available.

The list prepared by U.S Environmental Protection Agency contains 65 classes of pollutants in the priority list and said list comprises 129 specific substances, which are considered as hazardous waste\(^\text{24}\).

The following table elaborately describes the wastes based on hazardous characteristics\(^\text{25}\).

\(^{24}\) See encyclopedia of solid waste, page no 59. Chapter 4

\(^{25}\) See Encyclopedia of solid waste, chapter 4 entitled sources, types, and properties of hazardous waste found in municipal solid waste. Page no 102.
Table 1-426

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>40 CRF Sub part</th>
<th>Considerations</th>
<th>Hazard code</th>
</tr>
</thead>
</table>
| Lgnitability   | 261.21         | 1. Liquids with flash points of loss than 140°F (60°C)  
2. Non liquids liable to cause fires through friction, spontaneous chemical change. Etc.  
3. Lgnitable compressed gas  
4. Is an oxidizer | L            |
| Corrosivity    | 261.22         | 1. Aqueous wastes exhibiting a pH of < 3 or > 12.5  
2. Liquid waste capable of corroding steel at a rate greater than 0.250 in / year |             |
| Reactivity     | 261.23         | 1. Instability and readiness to undergo violent change  
2. Violent reactions when mixed with water.  
3. Formation of potentially explosive mixtures when mixed with water.  
4. Generation of toxic fumes when mixed with water.  
5. Cyanidi or sulfide |             |

Hazardous waste includes industrial waste, biomedical waste, mining waste and also municipal hazardous waste.

**a. Industrial and mining waste**

Industrial waste encompasses a very wide range of materials, like General factory rubbish, packaging materials, organic wastes, acids, alkalis metalliferous sludge, metals, plastic, rubber, paper, wood, cloth, chemical residues, and waste that is generated during the processing, packing and shipping activities etc. Discharges from petroleum refining

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26 Supra note no 11, page 224
and other related industries are also considered as industrial waste. However industrial wastes are well described in the following table.

**Table 2-4**

**Sources and types of industrial wastes**

**SCHEDULE 1**

**Table 3.2**

**Sources and types of industrial wastes**

<table>
<thead>
<tr>
<th>Code</th>
<th>SIC groups classification</th>
<th>Waste generating processes</th>
<th>Exp Ected specific wastes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ordnance and accessories</td>
<td>Manufacturing and assembling Processing, packaging, shipping</td>
<td>Moials, plastic, rubber, paper, wood, cloth, chemical residues</td>
<td></td>
</tr>
<tr>
<td>Food and kind rod products</td>
<td>Weaving, processing, dyeing, and shipping</td>
<td>Meats, tutu, oils, bonus, offal, vegetables, fruits, nuts and shells, cereals</td>
<td></td>
</tr>
<tr>
<td>Textile mill products</td>
<td>Cutting, sewing, sizing, pressing</td>
<td>Cloth and fiber residues</td>
<td></td>
</tr>
<tr>
<td>Apparel and other finished products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber and wood products</td>
<td>Sawmills, millwork plants, wooden container, miscellaneous wood products, manufacturing</td>
<td>Cloth, fibers, metals, plastics, rubber</td>
<td></td>
</tr>
<tr>
<td>Furniture, wood</td>
<td>Manufacture of household and office furniture, partitions office and store fixtures, mattresses</td>
<td>Scrap wood, shoving, sawdust; in some instances metals, plastics, fibers, glues, sealers, paints, solvents</td>
<td></td>
</tr>
<tr>
<td>Furniture, metal</td>
<td>Manufacture of household and office furniture, lockois, bod-springs,</td>
<td>Those listed under code 24; in addition, cloth and padding residues</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asphalt and tars,</td>
<td></td>
</tr>
</tbody>
</table>

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27 supra note no11, 260.
<table>
<thead>
<tr>
<th>Industry Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper and allied product:</td>
<td>newspapers publishing, printing, lithography, engraving, and bookbinding</td>
</tr>
<tr>
<td>Printing and publishing</td>
<td>manufacture and preparation of inorganic chemicals (ranges from drugs and soaps to paints and varnishes, and explosives)</td>
</tr>
<tr>
<td>Chemical and related products</td>
<td>manufacture of paving and roofing materials</td>
</tr>
<tr>
<td>Petroleum refining and related industries</td>
<td>manufacture of fabricated rubber and plastic products</td>
</tr>
<tr>
<td>Rubber and miscellaneous plastic products</td>
<td>leather tanning and finishing; manufacture of leather bolting and packing</td>
</tr>
<tr>
<td>Leather and leather products</td>
<td>felts, asbestos, paper, cloth, fiber, scrap rubber and plastics, lampblack, curing corn-pounds, dyes</td>
</tr>
</tbody>
</table>

Mining waste includes by-products of extraction process, top soil, rock and dirt. It also includes the materials contaminated with the small quantities of metals and coal. Mining wastes are considered hazardous waste and these wastes enter the marine through run-off and water ways.
b. Biomedical wastes

Biomedical wastes are by-products of health care centers, hospitals, pathologies etc. It includes sharps, non sharps, blood body parts, chemicals, pharmaceuticals, medical devices and also radio active materials. Quantity and quality of these waste depends upon number of the patients, nature of activity E.g. Accumulation of biomedical wastes are different from diagnosis labs to the treatment centers. Similarly in clinical research and clinical trails the accumulation of biomedical waste is varying.

World Health Organization (WHO) classifies biomedical wastes into following categories they are

1. General Waste
2. Pathological Waste
3. Radio logical waste
4. Chemical waste
5. Pharmaceutical wastes
6. Sharps
7. Infections waste
8. Pressurized wastes.

As per available documents, modern hospitals produce wastes that ranges from 1.5 to 2.5 kg per day, per bed. It constitutes plastics, paper, glass, linen, metals, human flesh and organic tissues. However the percentage of waste varies from hospital to hospital.

Common hazardous substances found in biomedical waste are,

1. Chemotherapy and anti neoplastic chemicals
2. Radio Nuclides
3. Solvents
4. Mercury
5. Waste anesthetic gases (however it is not a solid waste)
6. Cleaning and maintenance chemicals and supplies e.g. Chlorine, paint, insecticides phenyl.
7. Other Toxic corrosive and miscellaneous chemicals.²⁸
8. Photographic Chemicals Etc.

Normally Biomedical wastes are handled and treated separately. However, poor and inadequate handling or management of this waste brings harmful effects to the health care workers, waste handlers, patients and the community in general. In addition, indiscriminate disposal of incinerator ash residues which contains highly toxic substances reaches the marine environment through run-off and that cause harm to marine ecology. Further leachet from improper waste treatment residues leads to the contamination of Ground water system. Hence leachet from coastal treatment facilities effect the coastal treatment facilities effect the coastal Ground water course and there by the marine ecology. However, very little quantity of Bio-medical waste is directly dumped in to the marine water. The following table provides guidelines for the disposal of bio medical waste.

Table 3-4²⁹

(See Rule 5)

CATEGORIES OF BIO-MEDICAL WASTE

<table>
<thead>
<tr>
<th>Option</th>
<th>Waste Category</th>
<th>Treatment &amp; Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category No. 1</td>
<td>Human Anatomical Waste (human tissues, organs, body parts)</td>
<td>incineration/</td>
</tr>
<tr>
<td>Category No. 2</td>
<td>Animal Waste (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, wastes generated by veterinary hospitals, colleges, / discharge from hospitals, animal houses)</td>
<td>deep burial incineration/deep burial</td>
</tr>
<tr>
<td>Category No. 3</td>
<td>Microbiology &amp; Biotechnology Waste (wastes from laboratory)cultures, stocks of specific, of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production biological, toxins, dishes and devices used for transfer of cultures)</td>
<td>local autoclaving/micro-waving/incinerations</td>
</tr>
<tr>
<td>Category No. 4</td>
<td>Waste sharps (Needles, syringes, scalpels, blades, Glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)</td>
<td>Disinfection (chemical treatment/autoclaving/micro- waving and mutilation/shredding)</td>
</tr>
<tr>
<td>Category No. 5</td>
<td>Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)</td>
<td>incineration/destruction and drugs disposal in secured landfills</td>
</tr>
<tr>
<td>Category No. 6</td>
<td>Solid Waste (Items contaminated with blood,</td>
<td>Incineration autoclaving</td>
</tr>
</tbody>
</table>

²⁹ S.C. Santra, Environmental sciences chapter 15 entitled solid wastes, New Central Book Agency. Pages no 258
and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood) /microwaving

<table>
<thead>
<tr>
<th>Category No.</th>
<th>Description</th>
<th>Disposal Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Solid Waste (wastes generated from disposable items other than the waste shapes such as Tubing’s, catheters, intravenous sets etc.)</td>
<td>Disinfection By chemical treatment /autoclaving microwaving and multination/shredding</td>
</tr>
<tr>
<td>9</td>
<td>Incineration Ash (ash from incineration of any bio-medical waste)</td>
<td>disposal in municipal landfill</td>
</tr>
<tr>
<td>10</td>
<td>Chemical Waste (chemicals used in production of biological, chemicals Used in disinfection, as insecticides, etc.)</td>
<td>chemical treatment and discharge into drains for liquids and secured landfill for solids</td>
</tr>
</tbody>
</table>

4. Radio Active Waste

Radio active waste mainly arises from the nuclear power plants and smaller quantities are derived from military sources and also from a variety of uses in medical, industrial, university establishments.

Some radio activity exists in the oceanic water itself. This natural radio activity is either introduced by cosmic gamma ray bombardment or by leaching from radio active rocks in the earth, but the major source of radiation in marine environment has been the fallout from atmospheric testing of nuclear weapons which began in the late 194030.

Further radio active wastes can be classified either according to their radio active properties or according to the source from which they are originated.

30 Though as early as the U.S operated a plutonium generating nuclear reactor in Washington Since the signing of the partial test ban treaty in 1963 radiation from this source has been decreasing only China continues to conduct atmospheric tests, France ceased doing so in 1974.
1. Low – level radio active waste, generally consists of contaminated laboratory debris, biological materials, building materials and uranium mine failings.

2. High level Radio active waste includes spent fuels from nuclear power reactors, together with liquid and solid residues from re-processing of spent fuels.

However, in most countries radio activity of effluents has decreased since 1985 in comparison with that of 1980. Even though total activity has fallen by more than 50% in UK, the activities of effluents of UK reactors remain higher than that reported from reactors in other countries.\(^{31}\)

5. Solid wastes that gets generated due to vessel based sources due to the and sea bed activities

The term vessel sources have been well defined in 1972 convention entitled prevention of marine pollution by dumping of wastes and other matter-1972. According to this convention vessel means water borne or air bore craft of any type what so ever.\(^{32}\) This expression includes air craft and floating craft whether self – propelled or not. Therefore pollutants from this source include all kinds of waste that has been dumped by the air borne or water borne crafts. Vessel based waste is very much similar to the municipal solid waste like, human waste, paper, plastic, wooden, cardboard, cotton, cloths, oil, crude oil, etc.

There are about 15 million water crafts that are navigable on water and their combined waste discharges are equivalent to a city with a population of 2, 00,000. Therefore the vessels are also contributing considerable quantity of pollutants to the

\(^{31}\) Supra note no 29.

\(^{32}\) Article 3(2) of prevention of marine pollution by dumping of wastes and other matter 1972
marine environment. But many conventions are silent about the regular discharges of waste from the vessels.

b. Sea bed activities

Sea bed activities include ocean mining, drilling for the purpose of exploration and exploitation of oceanic resources etc. Major threat to the seafloor is the displacement of silt sediments that cover the ocean bottom. Further nodule pick up devices scrape the soil of the floor from a depth of 2 to 45 centimeters, depending on the system employed to scarring the bottom of the ocean floor. These nodules pick – up devices immediately kill the benthic or bottom living organisms that inhabit in the ocean floor. In addition the surrounding areas are seriously threatened or killed by overhanging sediments in the plume. The later case is particularly true for organisms with slow reproductive cycles E.g.: Benthic clam reaches sexual maturity after 200 years. Further ocean currents carry the sediments to the more distant part of the oceans which destroys the ocean bottom ecoculture33.

In addition dredge spoils contribute significantly to the marine pollution. Solid materials removed from the bottom of water bodies to improve the navigation are called as dridge spoils. It includes sand, silt, clay, rock and pollutants that have been deposited from municipal and industrial discharges.

33 Alexander and merle post, deep sea mining and the law of the sea, British publishers, Page no 58, chapter 4
6. Atmospheric dumping and soil erosion

Atmospheric dumping means air borne small particles that arise due to the various human activities on the land. Therefore, usually, the atmospheric dumping can be considered as a land based waste.

Further, sediments and erosion contents carried by run – off enter the marine, in a great volume. The volume of suspended solids reaching U.S water is approximately seven hundred times greater than the total sewage discharge. Sediments are washed from croplands, unprotected forests, overgrazed pastures, strip-mines, roads or bulldozed urban areas. However agricultural development increases land erosion rates four to nine times over what they were before. Construction may increase this rate at hundred times\(^3\)\(^4\).

All these kinds of solid waste enter the marine ecology from various routes like direct discharges, through pipelines, by run – off, due to deliberate dumping or via water way or due to accidents. Etc.

From the above information it is apparent that, nearly 90\% of solid waste that enter the marine environment is generated due to the various human activities on land. One can attribute increased land based pollution to three factors. They are,

A. Population Growth,

B. changes life style,

C. rapid growth of industries

\(^3\) David,p Currie, pollution cases and materials. Printed Hall Indra, Page no 5.
Population growth, has led to a proportionate increase in solid waste generation. In addition, mankind’s basic need for food, shelter and fuel has caused a severe environmental stress that will worsen the situation drastically in future.

The changed life style has given rise to the throw away convenience and there by has contributed to the increased land based pollution.

Industrialization and evolution of various environmental legislations to govern the activities of industries at various levels have given rise to a problem of waste disposal, as much legislation has prohibited the open burning of waste. Such prohibitions resulted in to the water way discharges of untreated wastes. Ultimately these wastes reach the marine sooner or later. In addition, various industrial activities have brought an increase in the direct discharge of contaminants originating from newly developed facilities.

US Environmental Protection Agency (EPA) has estimated that most of the Ground water contamination caused due to the leachet that arises in the land filling. So the leachet formation from coastal land filling facilities pollutes the marine ecosystem severely.

V. EVOLUTION OF SOLID WASTE MANAGEMENT

In the primitive society, disposal of solid waste was not a major problem, because the population was small and the land available for assimilation of waste was large. However problems relating to disposal of waste started during the middle ages. During this time, the improper disposal practices like throwing waste in to the streets, road ways and to the vacant lands which led to the breeding of rats and there by caused many deceases like plague.
In the 19th Century, the public health control authorities have realized the evil effects of improper and unplanned waste disposal and hence started to collecting and disposing the waste in a sanitary manner. In a technological society, growing population, industrialization, and their needs have been associated with the accumulation of unwanted waste materials. According to a recent estimation, UK alone produces 400 million tones of waste where the annual production of rubbish alone exceeds 300 Kg per person.

Today the constant increase in waste generation has become a global problem. The UK, Germany, France and Italy produce 85% of the total volume of waste, and the European Union produces 87% of the dangerous substances. The waste is generally disposed by means of landfill, incineration, composting, ocean disposal, pyrolysis, gasification, anaerobic Digestion process etc.

**VI. SOLID WASTE MANAGEMENT TECHNIQUES**

Solid waste management includes collection, segregation, transportation, reuse and the disposal of the residual matter of solid waste. However, the safe and reliable long-term disposal of solid waste residue is an important component of integrated solid waste management.

Historically, solid waste has been dumped into the soil in the earth’s crust or deposited in the oceans. However, many countries have officially banned the disposal of municipal solid waste in the ocean. E.g., United States officially abandoned the ocean.

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35 Cutler L. Susan, Environmental Risk and Hazardous, Priyentee Hall Indra,
36 Residual matter means, solid material remaining after the separation of waste materials or after the completion of a chemical or physical process such as burning evaporation, distillation or filtration.
37 Integrated solid waste management is based on a consideration of source reduction, recycling, waste transformation and disposal arranged in a hierarchical order. It mainly deals with purposeful, systematic control of the functional elements of waste generation, waste handling, separation and processing at the source; till it’s final disposal.
disposal of municipal solid waste in 1933. However following are the effective methods of solid waste management.

1. Composting
2. Land filling
3. Ocean disposal
4. Incineration
5. Pyrolysis
6. Gasification
7. Wabio Anaerobic Digestion process.

1. Composting

Composting is a slow and natural process, where mixed bacteria, fungicides, insects and worms consume plants and animal wastes and slowly convert them into a soil like substances. This kind of composting soil is very much beneficial to plant growth. Normally this soil is used for agricultural purposes. Compost provides energy, minerals, nutrients and micro-nutrients, useful microbes and water retaining humus to the soil, composting can be done by aerobic and anaerobic process. In aerobic, process, conversion of biodegradable solid waste into soil, requires 45 to 60 days. Further vermin composting is a process where earth worms consume decayed plant and animal wastes with the help of bacteria on a small scale in decentralized location. However it is best suited to segregate biodegradable wastes.
2. Land filling

Land filling has been the most economical and environmentally acceptable method for the disposal of solid waste, which has been adopted throughout the world. Land filling can be defined as “physical facilities used for the disposal of residual solid wastes in the surface soils of the earth\textsuperscript{38}. Solid waste management through land filling includes plan, design, operation, and closure and post-closure management of landfills.

\textit{Advantages of land filling:}

1. Economic form of solid waste disposal

The installation cost of the land filling facility would be about 10\% of a normal waste borne sewage system. Hence solid waste disposal by using the land fill is most economic form of solid waste management.

2. Land filling facility does not rely on the availability of fresh water:

Indeed, decomposition process of solid waste needs water. But the land filling facility does not depend on the availability of fresh water. Kitchen water or drainage water can also pass to the digester of the land filling facility.

3. Continuous working:

Digestion system of land filling facility does not depend on any manual effort. Hence even during the time of civil unrest and strikes the digestes keep on working.

\textsuperscript{38} Holusha\textit{.j, solid waste engineering principles and management issues }, Page no 362, part4.
Disadvantages of land filling system

Though the land filling facility is an economic and most acceptable form of solid waste management, it is also not far from disadvantages. The prime disadvantages of solid waste management through landfills are as follows.

1. Undue locking of valuable land for long time:

   Increased population not only produces huge quantity of wastes but also needs huge land for various purposes including space for proper and effective waste disposal. Therefore the balance between waste disposal and conservation of land is very much essential. But land filling facility needs land based on the quantity of solid waste that intends to be disposed in a land filling. Further once a piece of land used for land filling facility then such land is not useful for long time.

2. Contamination of ground water

   Leachet formation in the Land filling facility contaminates ground water system. Leachet that is formed in land filling facility is highly toxic and hazardous. The noteworthy point is that Ground water systems are interconnected. Hence leachet released from coastal land filling facility enters the coastal Ground water system and finally causes marine pollution.

Types of land filling

In earlier times there was only one landfill facility called sanitary land fill, but in the present technological world, land fill can be classified into two categories, they are.

1. Sanitary landfill
2. Secure landfill

39 Leachet means, the liquid collected at the bottom of the land fill facility.
1. Sanitary landfills: It is an engineered facility for the disposal of municipal solid waste. These facilities are mainly operated to minimize public health hazardous and environmental impacts.

2. Secure landfills: These are the landfills which are specially designed for the disposal of hazardous waste.

   Indeed, landfilling is the most commonly used and well recognized mode of wastes disposal. But leachate that is released from these landfills enter the ground water and cause damage to water course. Normally leachate is the result of percolation of precipitation of uncontrolled run-off and irrigation water into the landfill. Leachate contains a variety of chemical constituents derived from the solubilization of the materials deposited in the landfill and from the products of the chemical and biochemical reactions occurring within the landfill. These chemicals enter the groundwater and cause contamination of receiving water. In case of coastal landfills these chemicals enter the marine via connectivity of groundwater course. If landfills are not properly closed then waste will be carried away by the run-off, which further adds to the marine pollution. Therefore technical inability relating to the design of secure landfills should be resolved.

3. Ocean disposal

   It is one of the most recognized and economic forms of waste disposal. In fact all the waste generated on the land reach the marine sooner or later, either directly or indirectly. Therefore marine is the ultimate dump site for all kind of planetary wastes.
Ocean dumping includes direct discharges through the pipelines, direct dumping of wastes either in a packed or unpacked from, regular discharges by the vessel, atmospheric dumping of waste, dumping through run-off, water way. Etc.

UNCLOS – III- 1982, has elaborately defined the term ocean dumping as follows

1(5) (a) ‘Dumping means’

(i) Any deliberate disposal of waste or other matter from vessels, aircraft, platforms or other man-made structures at sea;

(ii) Any deliberate disposal of vessels, air craft, platforms or other man made structure at sea.

Article (5)(b) “Dumping does not include, (i) the disposal of waste or other matter incidental to or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment other than wastes or other matters transported by or to vessels, aircraft, platforms or other man-made structures at sea operating for the purpose of disposal of such matter or derived from the treatment of such waste or other matter on such vessels, air craft, platforms or structures.

(ii) Placement of matter for a purpose other than the mere disposal there of provided that such placement is not contrary to the aims of this convention.

Thus, UNCLOS III 1982, which is considered as elaborate legal document to cover all types of marine pollution, contains many loopholes. It does not cover the incidental discharges and discharges due to the normal operation of vessels, aircrafts, platforms or other man – made structures at sea and their equipment at the sea.

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40 Article 1 paragraph 5.
According to UNCLOS –III-1982, incidental$^{51}$and regular discharges from vessels, platforms and from structures at sea are not considered as ‘dumping’. Hence in order to consider a discharge or disposal as dumping one should pay attention as to whether such disposal is intentional or incidental. Recent years have seen wanton development and according to a recent estimation, by 2025 the oceans of the world will be completely used for many purposes. Therefore there should not be any room for exceptions in the laws relating to marine pollution. At least there must be certain guidelines, polices, procedures even to govern incidental and regular discharges. However complete irradiation of dumping of waste in to the oceans is not possible and such restriction imposes much pressure on sovereign states, where they have to balance between the effective management of waste and proper utilization of land. Therefore each state should give importance to the alternate waste management methods where it can convert the waste in to energy. In addition every disposal and discharges should be governed by uniform laws and state should follow those laws in good faith.

**VII. FACTORS THAT FACILITATE NATIONAL DECISIONS TO EXPAND OCEAN DISPOSAL PRACTICES**

1. Citizens’ resistance to local land fills
2. Technical feasibility of land disposal alternatives
3. Relative cost considerations of available options.
4. Lack of scientific knowledge regarding ocean eco-system processes.

The very first factor-that encourages the ocean disposal of waste materials is the resistance of citizens to the local land disposal operations.
Certain segments of society have always asserted that, the ocean should be used as depository for waste, because it possesses limitless assimilative capacity. And so it can safely absorb large amount of waste and further they have contended that the ocean disposal of contaminated dredge spoils may prove less harmful, than that of other land based disposal methods. Secondly, public dis-satisfaction with the old Unscientific and in complete land based solid waste management methods. Further odor from insufficient waste treatment facilities lead to the increased anxiety about the existing waste treatment facilities. Therefore to curb the ocean disposal practices importance should be given to the integrated solid waste management by applying advanced scientific approaches. To this end said area tenders more research activities and inventions in order to introduce new and advanced techniques to improve the existing solid waste management systems and also to introduce the new, effective and economic form of waste disposal system.

4) Incinerations

It is controlled processes by which solid, liquid or gaseous combustible wastes are burns and converted into gases, and the residue produced during this process contains little or no combustible material. Normally the residue that is produced during incineration ash with some chemicals and heavy metals are normally disposed in to the landfills or dumped in to oceans, which pollute the marine severely. In a recent incident that was reported by the government of Haiti, where a vessel of international registry off loaded ash near the sea side city of ‘Go naives’[^41].

Such waste often contain heavy metals and other toxic substances which do not impair the quality of the resource base but also enter the human body through biological magnification and thereby poses severe health disorders.

5) Pyrolysis

Pyrolysis is an irreversible chemical change caused by the action of heat in the absence of oxygen. The said process offers distinct advantages like compactness, simple in design, low pressure operation, low wastage and high conversion i.e. more than 80%. It is a thermal decomposition of organic matter in the absence of air.

6) Gasification

Gasification conversion technology is very much similar to pyrolysis. Gasification converts solid or liquid into gaseous fuel without leaving any solid residues. The gasifier is essentially a chemical reactor. Where various complex physical and chemical processes takes place where biomass gets dried, heated and pyrolysed, particularly oxidized and reduced to gases. The typical composition of producer gas obtained from municipal solid waste gasification on volumetric basis is carbon monoxide 18-22%, hydrogen 13-20% methane 1-5% carbon dioxide 10-13% nitrogen 45-55%.

7) Wabio Anaerobic Digestion process

Wabio a process is based on anaerobic digestion that has been developed by eco-technology JVV-OY of Finland. Normally, municipal solid waste is treated by this process for power generation.
The wabio process consists of

(i) Reception and sorting.

(ii) Mechanical conditioning

(iii) Anaerobic digestion

(iv) Power generation

(v) De-wathering of slurry to produce organic fertilizer.

Advantages of wabio process

(1) Wabio process takes place in closed vessels and consequently there is no odor, nuisance or leakage of biogas into the atmosphere. The process has no impact attacks no birds or vermin’s such as rats, mice. It becomes an asset and especially important to nigh bourse of the plants.

(2) The high quality biogas of the wabio process is converted into electricity in a power plant through gas engine generators. The wabio plant produces power for sale, in addition to municipal solid waste management.

(3) The quality of wabio humus is very high. In the wabio process all disease causing micro organisms are eliminated. The maturity grade is IV or better according to the German classification. The organic matter content is 30-40%

(4) Land area required for a wabio plant is only 20% of that required for the anaerobic composting installation.

(5) Anaerobic digestion by the wabio process requires only 20-25 days as compared to a minimum of 180 days required for aerobic methods.
VIII. CONCLUSION

The world economy not only produces enormous amount of goods, but also produces huge quantity of waste. Solid waste generation is a consequence of life and based on the population, percapita income, living style of a country. Solid waste generates from various sources and always in mixed form, hence segregation of solid waste based on their nature and environmental impact itself is a complicated task. In recent years world community is facing the problems relating to the effective disposal of land based solid waste, because in the present scenario world community has to balance between the proper utilization of land and effective disposal of waste. Many people opine that marine is the most suitable place for all planetary waste and it is also an economic form of waste management system in comparison with other form waste management methods. The rationale behind such presumption is that, ocean possess huge assimilative capacity, hence it can assimilate any quantum of waste. But indeed, though ocean is huge, and possesses self purification capacity but it can not assimilate huge quantum of waste without adverse effect. Best examples are, Global warming and Tsunami 2004. Tsunami 2004 was one of such disasters which dumped huge quantum of waste to marine, after 2years Oceanic Research Center found the decreased oxygen in the Tsunami affected areas with some other evil effects. Hence marine is huge, unique, and possess 80% of total life but it is part of nature and earth surface therefore not far from the truth that ocean cannot assimilate waste without changes. Such small changes would lead to severe ecological imbalance. Hence importance should be given to the segregation of solid waste at the source itself. Advanced technology should be found to reuse the solid waste as a source of energy and as raw materials for the production of eco friendly goods.
Importance should be given to stop the solid waste at the source itself. Strict norms should be framed to protect the various pathways to the marine. Nations should take the initiations to provide awareness to the public about the consequences and evil effects of the solid waste generation and its inefficient disposal. More than 50% of the total population is habited in coastal area as a consequence the waste generation is also high and ineffective management of landfills directly affects the marine environment. Hence Effective construction and management of land fills at both pre-closure and post-closure level is imperative.